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THE *Journal of Wildlife Rehabilitation* is designed to provide useful information to wildlife rehabilitators and others involved in the care and treatment of native wild species with the ultimate purpose of returning them to the wild. The journal is published by the International Wildlife Rehabilitation Council (IWRC), which invites your comments on this issue. Through this publication, rehabilitation courses offered online and on-site in numerous locations, and its outreach to those in the profession, the IWRC works to disseminate information and improve the quality of the care provided to wildlife.



ON THE COVER:

Hooded crow *(Corvus cornix)* walking among fallen leaves.

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LEFT:

Koala *(Phascolarctos cinereus)* **and her joey.**

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INTERNATIONAL WILDLIFE REHABILITATION COUNCIL

Providing evidence-based education and resources on wildlife rehabilitation to move the field of wildlife rehabilitation forward; to promote wildlife conservation and welfare; and to mitigate human-wildlife conflicts worldwide, through better understanding of wild animal ecology, behavior, and welfare.

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EDITORIAL

Vulnerable

Spreading along the Pacific Flyway, highly pathogenic avian influenza H5 subtype (HPAI H5) virus moved through the west coast of South America from its initial discovery point in Columbia in October of 2022, moving 6000 kilometers in 3 months. Detected more recently east of the Andes, the virus may have come over the mountains or been separately carried down the Central American flyway. More than 500,000 wild birds and 20,000 wild mammals have been reported dead as of August 2023. The Peruvian population of Peruvian pelicans (*Pelecanus thagus*) has decreased by an estimated 36% and the virus is thought to be the reason for a 9% or more decrease in the South American sea lion (*Otaria flavescens*).

There is a real concern that the virus will move into Antarctica, with its vast populations of breeding birds.

The threat of avian influenza is so significant that in 2005, the OFFLU network of avian influenza expertise was formed by the Food and Agriculture Organization of the United Nations and the World Organisation for Animal Health.

Recommendations from the OFFLU ad hoc group include further investigating of HPAI vaccines in wild birds, identifying and recording detailed data from mortality events, removing carcasses, and limiting further anthropogenic spread.

Wildlife rehabilitators are already playing a part in all four of these recommendations. Additionally, some rehabilitation centers are researching protocol for caring for birds affected by HPAI.

Meanwhile, in the Northern Hemisphere, Californian rehabilitators are dealing with a larger than usual botulism outbreak, even beyond the "usual" annual outbreak, which is a significant morbidity and mortality event. Among the events fueling this year's outbreak were the heavy precipitation in early 2023 and warm late summer temperatures. This is not the first time California has had an extreme botulism outbreak. In 1983, 30,000 birds died at Tulare Lake alone.

I wonder if the frequency will continue to increase as we look to warmer temperatures and changing precipitation patterns affecting lands like Tulare Lake—lands that humans have colonized for intensive agriculture with all the attendant outputs, now being reclaimed by the landscape. Could returning some of these historic wetlands to their ecological purpose help mitigate disease response? How will wildlife rehabilitation look 10 or 30 years from now as we are increasingly called upon to respond to larger-scale disaster events? How do we remain prepared, given our already limited resources?

While to the best of my knowledge neither of these events can be linked directly and exclusively to climate change, we know that changing temperatures and weather patterns have had an effect on both disasters. I recently came across yet another new phrase, needed to describe our modern world: climate vulnerability. I fear the coming years will see many new phrases enter our lexicon.

But just as clear as these changes, is the importance of wildlife rehabilitation in monitoring and mitigating the effects of climate change on our biodiversity.

—Kai Williams
Executive Director

More info:
OFFLU statement and summary
Botulism outbreak at Tulare Lake

Wildfires in Greece Injure Over 400 Tortoises

THE HAGUE, NETHERLANDS *(September 11, 2023)*—Wildfires that started in July have now burned over 230,000 acres in Greece as of early September. After having received 400 tortoises since the fires started, wildlife center ANIMA reached out to IFAW who is in the process of deploying aid along with the French NGO SOPTOM, the Station for the Observation and Protection of Tortoises and their Environment.

Céline Sissler-Bienvenu, IFAW program director for Disaster Response & Risk Reduction at IFAW Europe, has noted that,

> The fires are under control, but the aftermath is truly devastating. The flames ravaged the landscape, scorching thousands of animals in its tracks. We are seeing slow-moving tortoises with burnt legs, shells and breathing problems as a result of toxic smoke inhalation. It's upsetting to see, but we are glad we are able to provide some help to these creatures alongside SOPTOM at least.

SOPTOM Director of Conservation & Science, Sébastien Caron, adds,

> Our research shows that tortoises will stick to their original habitat, even if it's been destroyed. These sedentary and philopatric animals are extremely hardy, but slow and with very low escape capacity, they are particularly vulnerable to disasters such as fires.



PHOTO ©ANIMA. USED WITH PERMISSION.

ANIMA team member rescues a **marginated tortoise** (*Testudo marginata*).

Potential Pennsylvania Wildlife Rehabilitation Funding

HARRISBURG, PA, USA *(September 15, 2023)*—Pennsylvania State Representative Tarah Probst (D) sponsored PA House Bill 1522 to fund Pennsylvania wildlife rehabilitation centers. The bill is cosponsored by 16 members of the state house. Speaking to ABC News, Representative Probst said,

> Everything they do besides their time costs money, and you know you can't rely solely on donors. You just can't. Volunteers are hard to find right now because, Lord knows, people are working two jobs to make ends meet. So this is something that the state can afford. They should take care of it because it's our native species.

The bill proposes that funds could be received through a grant program outlined within the bill. The memorandum Rep. Probst released with the bill in June states, "Wildlife rehabilitators are essential in treating and temporarily caring for injured, diseased, and displaced wildlife. These individuals also provide essential education in order to mitigate human–wildlife conflicts and promote stewardship of wildlife."

Wildlife Rehabilitation Grants Available

EUGENE, OR, USA *(September 5, 2023)*—This fall saw several grant opportunities for wildlife rehabilitators, including the California-specific Native Wildlife

Rehabilitation Grant (closing October 15); IFAW and Animal Help Now support for disaster recovery; and the Avangrid Foundation Wildlife Rehabilitation Grant program (closed September 25).

The annual Avangrid program started in 2016. In a press release September 5th, Avangrid Foundation Executive Director Pablo Colón said, "We're excited to launch this year's grant program right in time for National Wildlife Day. Last year our grant recipients utilized the funds they received to combat avian influenza, study copper toxicity, build new shelters, purchase nutritious food, and much more."

Black Summer Bushfire Survivor Spotted with Joey

SYDNEY, AUSTRALIA *(September 4, 2023)*—A koala that survived the 2019–2020 fires in Australia has been spotted with her second joey. She was released in April of 2020 after six months in care for fire-related injuries. She was spotted with a joey in spring of 2021 and has been again seen with a joey this spring.

Tree planting, wildlife rehabilitation, and collaborations with farmers and nonprofits have connected efforts to support koalas and other wildlife after the devastating and widespread fires. Tree planting efforts in New South Wales and Victoria have helped bring back habitat for these unique mammals. Signs of koalas have been seen in more than one of the recently planted regions.

U.S. Fish and Wildlife Service proposes federal protections for both species of western pond turtle under the Endangered Species Act

VENTURA, CA, USA *(September 29, 2023)*—The U.S. Fish and Wildlife Service today announced a proposal to list both species of western pond turtle, the northwestern pond turtle and the southwestern pond turtle, as a threatened species under the Endangered Species Act (ESA). The Service is also proposing a 4(d) rule, that would support conservation of both species. The northwestern pond turtle occurs in Washington, Oregon, Nevada, and throughout much of northern and central California. The southwestern pond turtle occurs in southern California from Monterey County south to Los Angeles, Riverside, and San Diego counties into northern Baja California, Mexico. The turtles use rivers, lakes, ponds, streams, other water sources, and terrestrial habitats throughout their lives.



PHOTO © USFWS PACIFIC SOUTHWEST REGION. PUBLIC DOMAIN.

Western pond turtles (*Actinemys marmorata*) and eggs.

Ongoing threats to both species include worsening drought conditions, habitat loss and fragmentation, and predation by invasive species such as non-native bullfrogs.

The Service reviewed the best available science to evaluate the status of both species by preparing a Species Status Assessment, including information provided by species experts.

The assessment found that although the southwestern pond turtle and northwestern pond turtle are likely to sustain populations in the wild in the near term, both species have increasing risk of extinction due to population losses, decreased genetic diversity, and a reduced ability to adapt to changing environmental conditions in the next half century, thus warranting listing as threatened under the ESA.

Ongoing conservation efforts continue to support populations of southwestern pond turtles and northwestern pond turtles in the wild. These include development of a range-wide management strategy by federal, state, and private partners to guide efforts to enhance, protect, and restore pond turtle habitat; collaboration with military installations to formalize management recommendations on thousands of acres of military land; and development of habitat conservation plans that provide landowners opportunities to assist in conserving the species and their habitats. For example, the state of Washington implemented habitat management and predator control measures while raising northwestern pond turtles in captivity for release into the wild to help boost populations.

The Service will seek public comment on this proposal. The documents will publish in the Federal Register on October 3, 2023, opening a 60-day public comment period. The Service will consider comments from all interested parties received by December 4, 2023. The proposal and the information on how to submit comments was opened October 3, 2023, and can be found at www.regulations.gov by searching under docket number FWS-R8-ES-2023-0092. ■

Causes of admission of birds of prey in a wildlife rehabilitation center in Puebla, Mexico (2015–2020)

Andrea Damián-Alcalá,[1] Andrés Estay-Stange,[1, 2] Álvaro Oidor-Méndez[1]

PHOTO © CAROLINE LEGG. CREATIVE COMMONS LICENSE.



Barn owl (*Tyto alba*).

Introduction

There are 87 species of raptors in Mexico, 57 diurnal and 30 nocturnal (National Commission for the Knowledge and Use of Biodiversity).[1] Raptors play an important role in agricultural production by controlling harmful species such as rodents, lagomorphs (hares and rabbits), and insects. They are also efficient predators of rodents that transmit infectious diseases.[2,3]

The main causes of the decline of raptor populations are anthropogenic activities such as deforestation, illegal hunting, pollution, agriculture, livestock farming, urbanization, and illegal trafficking. These activities threaten both the survival of raptors and the balance of their habitats.[4] These threats are reflected in the cases of collisions of birds of prey with power lines, towers, vehicles, and large windows, among others,[5] which cause various injuries such as closed fractures, exposed fractures, loss of limbs, malnutrition, behavioral problems, and neurological problems.

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ABSTRACT: We investigated the causes of raptor admissions to the Konkon Wildlife Conservation Center from 2015 to 2020. A total of 125 individuals of 23 different raptor species were admitted to Konkon for varied reasons and with different health problems. The main causes of admission were illegal sales, illegal possession, and trafficking (66.4%). The most frequent diagnosis was physical injury with a total of 63 records (50.4%), followed by nutritional problems with 35 records (28.0%), and ethological problems with 27 records (21.6%). The species with the highest number of records were the barn owl (*Tyto alba*) (16.8%) and the American kestrel (*Falco sparverius*) (12.8%). It was found that the causes of admission were associated with the diagnoses at entry of the birds. We encourage other rescue centers to check this trend in their populations. Relationships between the scientific community, wildlife rescue projects, and government agencies should be strengthened so that a broader analysis of the real effects of wildlife trafficking in Mexico can be performed.

KEYWORDS: causes of admission, illegal trafficking, raptors, rehabilitation

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Illegal wildlife trafficking has a direct and irreversible impact on ecosystems and their biodiversity. This can be observed in the steep decline in the populations of species with high commercial value seen in recent years.[6] The main factor behind illegal wildlife trafficking is thought to be market demand, which in turn is promoted by consumer groups driven by deeply ingrained social and cultural values.[7]

In recent decades, Mexico has focused its policies on promoting sustainable use schemes to prevent ecological benefits from conflicting with socioeconomic benefits. These efforts have been reflected in the development of legal frameworks and government structures that allow the implementation of these policies.[8]

As part of these efforts, the System of Management Units for the Conservation of Wildlife (SUMA) was created to address the need to establish collection centers for wild fauna that could house all the specimens of wild flora and fauna that were confiscated or delivered by individuals. The aim of these centers is to rehabilitate and release wild species to their place of origin, but also to keep in captivity those specimens whose reintroduction is not possible, providing adequate conditions for the legal reproduction of captive wildlife.[9] According to Mexican law, all wildlife received in the Units for the Conservations of Wildlife must be delivered through the Federal Attorney for Environmental Protection (PROFEPA).

Methods

The present study was carried out with data obtained from the Konkon Wildlife Conservation Center, authorized by the Ministry of Environment and Natural Resources (SEMARNAT) and established in Puebla, Mexico. The birds are admitted to this center through the PROFEPA. Injured birds are admitted for varied reasons, including accidents, illegal trafficking, and gunshot injuries, among others.

The process of receiving the birds is carried out by biology and veterinary specialists from the Wildlife Conservation Center and the Small Species Veterinary Hospital. Upon receiving each individual, a taxonomic identification is made, and the pertinent measurements are taken. A physical exam (body condition, physical lesions) is carried out, and a clinical diagnosis (based on the signs and symptoms presented by the bird within the first few hours) is made. If necessary, parasitological and radiologic studies are performed. Considering all the collected information, a rehabilitation program is established, and a projection is made of the initial possibilities of the bird to be reintroduced to the environment.

Surgical procedures and veterinary treatments are performed at the Veterinary Hospital for Small Species of the Autonomous University of Puebla by a veterinarian specializing in exotic bird surgery. The physiotherapeutic and nutritional rehabilitation treatments are carried out by biologists at the Wildlife Conservation Center.

All bird admission data from 2015 to 2020 were reviewed. Data from a total of 125 individuals from 23 species of raptors were included in the study.

The variables were divided into two groups (Table 1):

Causes of admission. The reasons why the wild raptors ended up in the attorney's office are as follows: illegal sale, illegal possession, or illegal trafficking (t), collision with vehicles, wiring, or buildings (c), injuries caused by firearms (f), fall from the nest (fn), unknown (un).

Diagnosis. A disease, condition, or injury was identified, and a clinical diagnosis was made: physical injury (pi), nutritional problem (np), or behavioral problem (ethological) (bp).

The data were grouped into contingency tables, and Fisher's exact test was performed to define whether the cause and diagnosis

TABLE 1. List of considered variables

VARIABLE	CODE	DEFINITION
CAUSES OF ADMISSION		
Illegal sale, illegal possession, or trafficking	t	Confiscated in sales centers or homes without legal documentation or transported illegally.
Collision with vehicles, wiring, or building	c	Collision with windows or buildings, entangled in electrical wiring.
Injured by firearms	f	Injured by firearms (gunshots).
Fallen from the nest	fn	Nestlings or juveniles found outside the nest.
Unknown	un	Found with injuries or behavioral problems with no probable cause.
DIAGNOSIS		
Physical injury	pi	Exposed and non-exposed fractures in one or more parts of the body, trauma, damaged or clipped feathers, cuts or superficial injuries, foot pad injuries, ectoparasites, clipped claws, muscle atrophy.
Nutritional problem	np	Malnutrition and dehydration to severe cases, hypovitaminosis, excess fat.
Behavioral problem (ethological)	bp	Imprinting, self-mutilation.

TABLE 2. Causes of admission of raptors in the wildlife rehabilitation Center Konkon (2015–2020).

SPECIES	CAUSE OF ADMISSION (See Table 1 for legend)										TOTAL	
	C		T		F		FN		UN			
	n	%	n	%	n	%	n	%	n	%	N	%
NOCTURNAL RAPTORS												
Barn owl (*Tyto alba*)(TA)	7	5.6	5	4.0	0	0.0	9	7.2	0	0.0	21	16.8
Great horned owl (*Bubo virginianus*)(BV)	2	1.6	2	1.6	0	0.0	2	1.6	1	0.8	7	5.6
Burrowing owl (*Athene cunicularia*)(AC)	1	0.8	4	3.2	0	0.0	0	0.0	0	0.0	5	4
Western screech-owl (*Megascops kenicottii*)(MK)	3	2.4	2	1.6	0	0.0	3	2.4	0	0.0	8	6.4
Mottled owl (*Ciccaba virgata*)(CV)	1	0.8	5	4.0	0	0.0	0	0.0	0	0.0	6	4.8
Ferruginous pygmy owl (*Glaucidium brasilianum*)(GB)	0	0.0	1	0.8	0	0.0	1	0.8	0	0.0	2	1.6
Northern Pygmy owl (*Glaucidium gnoma*)(GG)	0	0.0	1	0.8	0	0.0	0	0.0	0	0.0	1	0.8
Striped owl (*Asio clamator*)(ACl)	0	0.0	1	0.8	0	0.0	0	0.0	0	0.0	1	0.8
DIURNAL RAPTORS												
White-tailed kite (*Elanus leucurus*) (EL)	1	0.8	3	2.4	0	0.0	2	1.6	0	0.0	6	4.8
Cooper's hawk (*Accipiter cooperii*) (ACo)	2	1.6	7	5.6	0	0.0	0	0.0	0	0.0	9	7.2
Red-tailed hawk (*Buteo jamaicencis*) (BJ)	1	0.8	8	6.4	1	0.8	0	0.0	0	0.0	10	8
American kestrel (*Falco sparverius*) (FS)	0	0.0	16	12.8	0	0.0	0	0.0	0	0.0	16	12.8
Harris's hawk (*Parabuteo unicinctus*) (PU)	1	0.8	7	5.6	0	0.0	0	0.0	0	0.0	8	6.4
Roadside hawk (*Rupornis magnirostris*) (RM)	0	0.0	6	4.8	0	0.0	0	0.0	0	0.0	6	4.8
Crested caracara (*Caracara cheriway*) (CC)	0	0.0	4	3.2	0	0.0	0	0.0	0	0.0	4	3.2
White-tailed hawk (GA) (*Geranoaetus albicaudatus*)	0	0.0	3	2.4	0	0.0	0	0.0	0	0.0	3	2.4
Gray hawk (*Buteo plagiatus*) (BP)	1	0.8	3	2.4	0	0.0	0	0.0	0	0.0	4	3.2
Black hawk-eagle (*Spizaetus tyrannus*) (ST)	0	0.0	1	0.8	0	0.0	0	0.0	0	0.0	1	0.8
Turkey vulture (*Cathartes aura*) (CA)	0	0.0	1	0.8	0	0.0	0	0.0	0	0.0	1	0.8
Golden eagle (*Aquila chrysaetos*) (ACh)	1	0.8	0	0.0	0	0.0	0	0.0	0	0.0	1	0.8
Peregrine falcon (*Falco peregrinus*) (FP)	1	0.8	2	1.6	0	0.0	0	0.0	0	0.0	3	2.4
Aplomado falcon (F*alco femoralis*) (FF)	0	0.0	1	0.8	0	0.0	0	0.0	0	0.0	1	0.8
Merlin (*Falco columbarius*) (FC)	1	0.8	0	0.0	0	0.0	0	0.0	0	0.0	1	0.8
Total	**23**	**18.4**	**83**	**66.4**	**1**	**0.8**	**17**	**13.6**	**1**	**0.8**	**125**	**100**

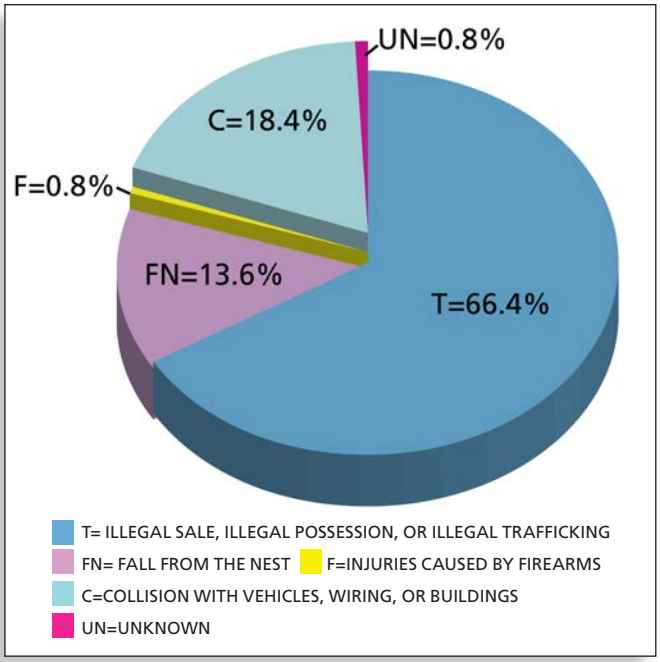


FIGURE 1. Percentage of causes of admission.

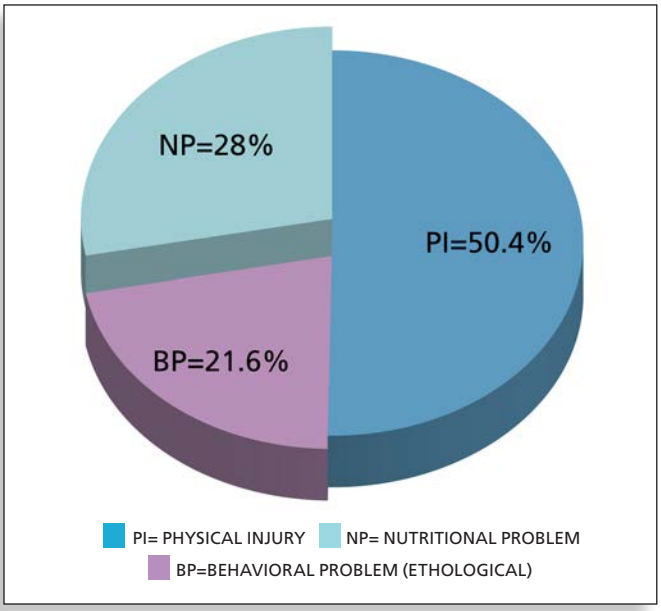


FIGURE 3. Percentage of diagnoses by cases.

TABLE 3. Admission and diagnosis by cases of birds of prey at the Konkon Rehabilitation Center (2015-2020).

CAUSE	DIAGNOSIS						TOTAL	
	PI		NP		BP			
	n	%	n	%	n	%	N	%
C	21	16.8	1	0.8	1	0.8	23	18.4
T	36	28.8	34	27.2	13	10.4	83	66.4
F	1	0.8	0	0	0	0	1	0.8
FN	4	3.2	0	0	13	10.4	17	13.6
UN	1	0.8	0	0	0	0	1	0.8
TOTAL	**63**	**50.4**	**35**	**28**	**27**	**21.6**	**125**	**100**

variables were independent or associated with one another, according to Cramer's V strength of association. To represent data trends more clearly, we used bipartite interaction network charts and pie charts.

Results and discussion

The results showed that the main cause of admission of raptors into the rehabilitation center (Figure 1; Table 2) was illegal sale, possession, and trafficking (n = 83; 66.4%), followed by collision with windows, buildings, or wiring (n = 23; 18.4%). The third cause was individuals falling from the nest (n = 17; 13.6%). The causes of injury were shooting (n = 1; 0.8%) and unknown (n = 1; 0.8%). The main cause of admission was expected to be the collision with windows, buildings, or electrical wiring, as reported by Mariacher,[10] Thompson,[11] Rodríguez,[12] and Martínez;[5] but it was not. It should be noted that the variable of illegal sale, illegal possession, or illegal trafficking had not been considered by similar studies. That it was the main cause of admission to the Konkon center is worrisome because it suggests that this problem is much greater in Mexico than in other parts of the world. In Mexico, the PROFEPA has the function of receiving injured animals found by citizens, as well as confiscating the animal victims of illegal trafficking, and also receiving animals kept illegally in captivity as "voluntary deliveries." The only way a conservation center can receive animals for rehabilitation is through the PROFEPA.

A total of eight species of nocturnal raptors were recorded in the present study, of which the barn owl, (*Tyto alba*) (TA), was the most frequent, with a total of 21 individuals (16.8%), followed by the western screech owl (*Megascops kennicottii*) (MK), (n = 8; 6.4%), and great horned owl (*Bubo virginianus*) (BV) (n = 7; 5.6%). A total of 15 different species of diurnal raptors were recorded, the main one being the American kestrel (*Falco sparverius*) (FS) (n = 16; 12.8%), followed by the red-tailed hawk (*Buteo jamaicencis*) (BJ) (n = 10; 8%), Cooper's hawk (*Accipiter cooperii*) (ACo) (n = 9; 7.2%), and Harris's hawk (*Parabuteo unicinctus*) (PU) (n = 8; 6.4%) (Table 2). Table 2 shows the total number of species admitted to the center along with the causes of admission in order of highest to lowest incidence.

In comparison with similar studies, the total number of species varied significantly between studies, depending on many factors such as the place, the geography of the area, the time at which they were found, among others. However, at least one species (*T. alba*) showed similar results in our study and in the studies by Molina,[13] Montesdeoca,[14] and Thompson.[11] *Tyto alba*, the barn owl, is one of the main species affected by anthropogenic activities. Since this species is cosmopolitan, that is, it is found in almost all parts of the world, it would not be unreasonable to think that they are the most affected ones mainly because they are more common throughout the world compared to other species that are migratory or endemic to certain regions. Considering that *T. alba* is in the category of least concern of the International Union for Conservation of Nature Red List, the results of the present study may not be considered cause for alarm. However, these results

indicate that the populations of this bird should be further studied to assess the possible effect of future anthropogenic activities and take action for its protection.

The diagnosis with the highest number of records turned out to be physical injury (pi) with a total of 63 records (50.4%), followed by nutritional problems (np) with 35 records (28%), and behavioral problems (bp) with 27 records (21.6%) (Figure 3). These three diagnoses were mostly present in individuals admitted as a result of illegal trade, illegal possession, or illegal trafficking (66.4%) (Table 3). Fisher's analyses indicated there was an association between the causes and the three diagnoses, physical injury ($P < 0.05$, Cramer's $V = 0.5$), nutritional problems ($P < 0.05$, Cramer's $V = 0.4$), and ethological problems ($P < 0.05$, Cramer's $V = 0.4$). In this case, Cramer's V analysis helps us to strengthen the association between the variables; the closer it is to the value 1, the stronger the association will be between them.

Although the variables that represented the diagnoses of the birds that were admitted to the center were considered complements to the causes and not causes in themselves, we should consider the studies by Molina[13] and Montesdeoca,[14] in which injuries represented the main cause of death in raptors. Similarly, physical injuries (pi), including trauma, affected many of the individuals recorded in our study and were directly associated with the main cause of admission. Even when other causes of admission were present, the diagnosis of physical injuries was predominant.

Conclusion

The present study showed that illegal trafficking has a strong impact on the causes of admission of birds of prey to rehabilitation centers. Despite the fact that Mexican legislation authorizes the legal sale of wild animals raised in captivity, illegal trafficking was reported as the main cause of admission of birds of prey to Konkon Rehabilitation Center. We still need to promote awareness about the risks that this practice poses not only for individual organisms, but also for wildlife populations and the ecosystem.

It is no coincidence that the majority of the individuals who were admitted to the center as a result of illegal trafficking presented with physical injuries and nutritional problems since the circumstances in which these practices are carried out tend to be violent and do not provide the conditions of care and feeding required by the birds. The reality is that thousands of animal lives are usually lost so that a minimum number of individuals reach the hands of consumers alive.

We encourage other rescue centers, associations, and parks in Mexico to conduct more studies and verify this trend in the populations of species that are admitted for rehabilitation. This would give us a much clearer picture of the situation in our country and could help develop new strategies to strengthen existing efforts to deal with wildlife trafficking.

It would also be important to inform and create awareness among the population about these problems, highlighting the important role that species such as raptors play in their habitat and all the ecosystem benefits that they provide. Promoting the use of

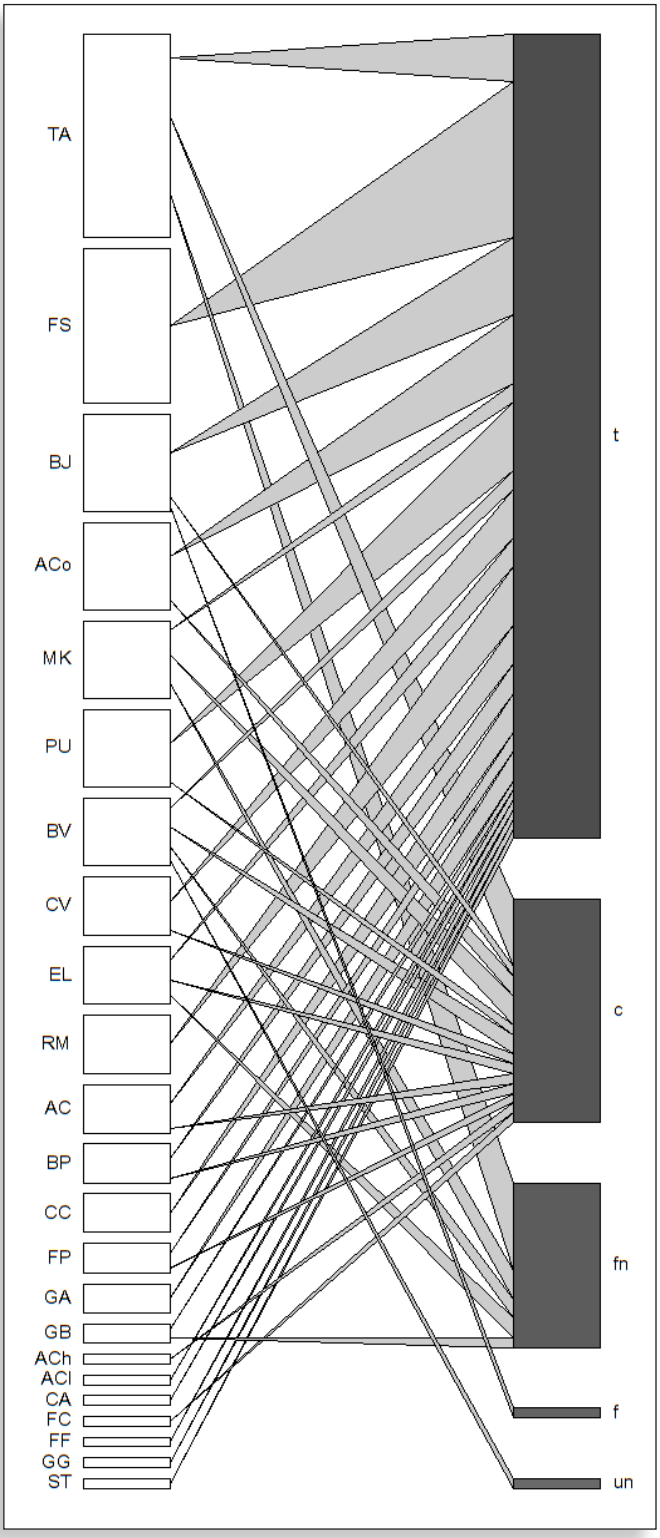


FIGURE 2. Cause of admission by species at Konkon (2015-2020).

tools such as citizen reporting could be especially useful, as well as providing guidelines for how to behave when encountering not only birds of prey, but also any wild animal. If people know what to do, which places or associations to go to, and which rescue centers are in each locality, the risks for these species can be considerably reduced. Environmental education programs should strive to make wildlife rescue information available to the public, as well as to efficiently train the professionals in charge of protecting wildlife in government agencies, civil associations, rescue centers, etc. The links between the scientific community, wildlife rescue projects, and government agencies should be improved to understand the real effects of wildlife trafficking in Mexico.

Literature Cited

1. CONABIO. Raptors, hummingbirds, and parakeets. Communiqué. 2015.
2. Ostfeld RS, Holt RD. Are predators good for your health? Evaluating evidence for top-down regulation of zoonotic disease reservoirs. *Front Ecol Environ.* 2004;2:13–20.
3. Figueroa RA, Corales ES, Cerda J, Saldivia H. Rodents, raptors and carnivores of Aysén. Agricultural and Livestock Service, Regional Government of Aysén, Coyhaique, Chile. p. 195.
4. Sarukhán et. al. Natural capital of Mexico. Strategic actions for its valuation, preservation, and recovery. National Commission for the Knowledge and Use of Biodiversity, Mexico; 2012.
5. Martínez J, Calvo J. Day and night raptors of the Region of Murcia. *AG Novograf.* 2006.
6. Nadal L, Carmona A, Trouyet M. Illegal wildlife trafficking. *SEMARNAT.* 2013.
7. Wyler L, Sheikh P. International illegal trade in wildlife threats and U.S. policy. CRS Report for Congress, Congressional Research Service, Washington, DC. 2008.
8. Reuter A, Mosig P. Trade and exploitation of wild species in Mexico: observations on management, trends and related challenges. *TRAFFIC Bulletin*. 2010. p. 80.
9. SEMARNAT (Ministry of Environment and Natural Resources). Centers for Wildlife Conservation and Research (CIVS). 2019. http://dgeiawf.semarnat.gob.mx:8080/ibi_apps/WFServlet?IBIF_ex=D3_R_BIODIV04_04&IBIC_user=dgeia_mce&IBIC_pass=dgeia_mce
10. Mariacher A, Gherardi R, Mastrorilli M, Melini D. Causes of admission and outcomes of Long-eared Owl (*Asio otus*) in wildlife rescue centres in Italy from 2010 to 2014. *Avian Biol Res.* 2016;9(4):282–286.
11. Thompson L, Hoffman B, Brown M. Causes of admissions to a raptor rehabilitation centre in KwaZulu-Natal, South Africa. *Afr Zool*. 2013;48(2):359–366.
12. Rodríguez B, Rodríguez A, Siverio F, Siverio M. Causes of raptor admissions to a wildlife rehabilitation center in Tenerife (Canary Islands). *J Raptor Res.* 2010;44(1):30–39.
13. Molina R, Casal J, Darwich L. Causes of Morbidity in Wild Raptor Populations Admitted at a Wildlife Rehabilitation Centre in Spain from 1995-2007: A Long-Term Retrospective Study. *PLOS ONE.* 2011;6(9):e24603.
14. Montesdeoca N, Calabuig P, Corbera J, Orós J. Causes of Admission for Raptors to the Tafira Wildlife Rehabilitation Center, Gran Canaria Island, Spain: 2003–2013. *J Wildl Dis.* 2016;52(3):647-652.

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Case study: Providing music as auditory environmental enrichment to improve the welfare of hooded crows during rehabilitation

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ABSTRACT:
Corvids, including the European hooded crow (*Corvus cornix*), account for a significant proportion of the thousands of wild birds admitted to wildlife rehabilitation centers worldwide. Limiting stress related to captivity and providing sufficient cognitive stimulation for these highly intelligent birds remains a challenge. In this study, we attempted to use music as environmental enrichment for crows rehabilitated in the Warsaw Zoo Rehabilitation Center (Ptasi Azyl) during the summer of 2019. Our results suggest that exposure to music had a calming effect on the birds, encouraging normal activities and reducing the incidence of stress-related behaviors.

KEYWORDS: animal welfare, bird rehabilitation, corvids, hooded crow, music enrichment.

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INTRODUCTION

The hooded crow (*Corvus cornix*), a typical example of a species exhibiting strong synurbisation, frequently interacts with humans but remains quite poorly studied with respect to its cognitive abilities and welfare in captivity. A sister species, the carrion crow (*Corvus corone*), is relatively rare in Poland and is observed mainly in the westernmost part of the country, which is the eastern limit of its range.[1] Research on carrion crows suggests that they have highly developed cognitive abilities, typical of corvids in general.[2,3]

J. Wildlife Rehab. 43(3):13–18. ©2023 The International Wildlife Rehabilitation Council.

In Poland, the hooded crow is considered a semi-migratory species, as the urban population stays for the winter and breeds there. In contrast, the rural population migrates from Poland, flying in western and southern directions.[4] The highest numbers of hooded crows are found in large urban agglomerations, in downtown buildings, old parks, and cemeteries.[5,6] Between 2001 and 2003, a 1.5-fold increase in the number of urban breeding pairs was noted in Wrocław,[7] with hooded crows found not only in parks and forests but also in the middle of the city, indicating the ongoing process of synurbisation.

The hooded crow is among the species most frequently brought to bird rehabilitation centers in Poland. During the breeding season, this often includes healthy fledglings mistakenly assumed to have been abandoned.

The literature on the welfare of wild corvids undergoing treatment in rehabilitation centers is scarce and mostly concerns their physical condition. Manuals such as the Minimum Standards of Wildlife Rehabilitation[8] mostly deal with disease control and housing requirements. The captive environment of a wildlife rehabilitation center aviary is a source of constant stress. Stimulus deprivation, lack of opportunities for free movement, and physical distress contribute to behavioral impairment and interfere with the normal development of cognitive skills. Environmental enrichment is thus an important factor in the welfare of rehabilitated birds.[9]

Hooded crows are vocal birds with excellent hearing sensitivity, particularly in the lower (<2 kHz) frequency range,[10] which is also the range where the human voice and many musical instruments operate.[11] The therapeutic benefit of music on humans is well documented and is used for stress reduction in the healthcare setting.[12] The beneficial effect of music as an auditory environmental enrichment strategy was demonstrated in farmed broiler chickens.[13,14] In this case report, we show the results of our pilot project using music to improve the welfare of hooded crows rehabilitated at the Ptasi Azyl Center in the Warsaw Zoo.

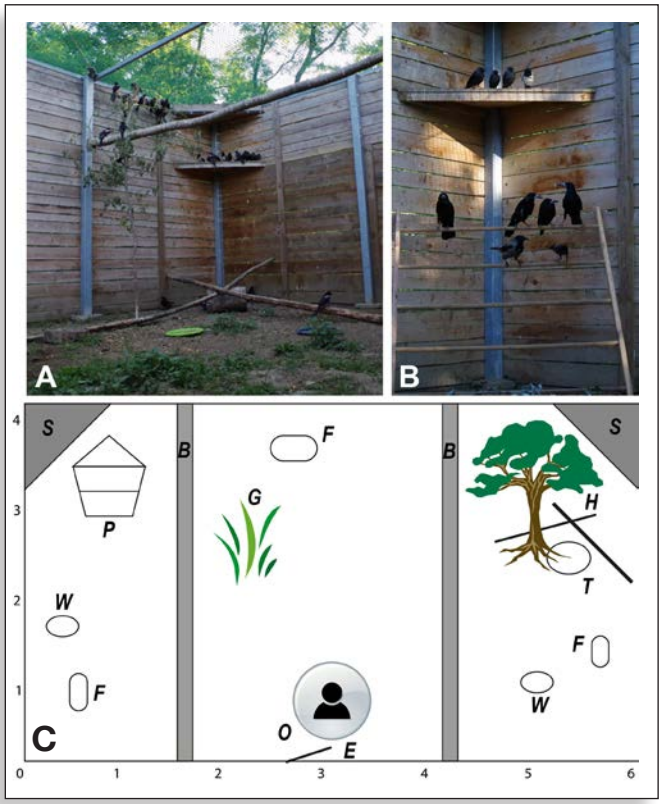


FIGURE 1. The aviary and the experimental setup.
(A) Right corner of the aviary – the observer's view: right shelf, dead tree branch, trunk, horizontal branches, green and grey trays, and grey water bowl. (B) Left corner of the aviary – the observer's view: left shelf and perch. (C) Schematic plan of the aviary and the experimental setup. Distances are shown in meters on both sides. The music source was at the observer (O) location. Symbols: S – shelf, P – perch, B – beam, G – high grass, T – trunk, H – branches, E – entrance, W – water, F – food. Photo and drawing credit: Aleksandra Jabłonska.

Methods

Fourteen hooded crows (*Corvus cornix*) under investigation were kept in one aviary together with 31 other corvids consisting of jackdaws (*Corvus monedula*) (n = 16), magpies (*Pica pica*) (n = 10), and rooks (*Corvus frugilegus*) (n = 5). All crows were two to three months old and had been undergoing treatment for at least one month after being admitted for injuries, diseases, or both. At the time of the study, they did not receive any medication, and their physical health was determined to be good. The study took place during the European summer in August 2019. Temperatures at the time of observation ranged between 20°C and 30°C. The birds in the study were housed in the bird rehabilitation center on the grounds of the Warsaw Zoo. The wooden walls of the aviary absorbed some of the sounds; however, city noise could be heard from afar. The aviary was far away from other buildings, so the birds were not exposed to the sounds of people or other animals. The genre of music was chosen based on qualitative research conducted on the same survey group one week before the actual study. The birds were exposed to classical music (Bach, Vivaldi, Schubert, Satie), 18th-century Scottish music (Les Musiciens De Saint-Julien), and jazz music (Louis Armstrong). The birds' reactions were observed. When jazz music was played, the crows appeared calm and interested. Specifically, the individuals moved closer to the observer and the sound source. Such behavior was not present during exposure to the other musical genres.

The experiment was conducted under two conditions: (1) the observer was sitting in silence in one location, and (2) the observer was sitting in silence in the same location as in the first condition but also next to a music source (Fig. 1). In condition (2), the music was played for one hour using the songs from the Spotify playlist "Milestones of a Jazz Legend: Louis Armstrong" in random order, and the volume was constantly kept at midrange throughout the study. The observations were carried out under each condition for five consecutive days between 8 am and 9 am, just before feeding. The food from the previous day was still present in the aviary. The observations were carried out according to the following pattern: 15 minutes of observation, 5 minutes of break. The complete list of detected behaviors (Table 1) was based on ethograms published

TABLE 1. COMPLETE LIST OF BEHAVIORS OBSERVED.

BEHAVIOR	DESCRIPTION
Standing	Standing on both legs on the ground
Walking	Taking more than one stride during 15 min of observation
Hopping	Moving on the ground with jumps
Flight	Flying from place to place
Flying up the wall	Flying towards the wall and bouncing off it
Pecking	Pecking object from the ground
Warning	Making a "caw" sound in response to external noises followed by flying to the higher perches in aviary
Single	Single "caw" sound
Multiple	Multiple "caw" sounds
Leave-me-alone	Making a "caw" sound in response to pecking by another individual
Listening	Tilting the head towards the source of sound
Begging	Opening beak wide, making begging calls, and flapping wings
Chasing and begging	Chasing an individual who has food, flapping wings, and making begging calls
Feeding	Giving food to the beak of a begging one
Running away	Moving quickly from the begging one
Drinking	Drinking water from the bowl
Eating	Taking food from the tray
Flying (with food)	Flying away with food in its beak
Food walking	Movement with food in its beak
Caching	Hiding food
Sleeping	Sitting with head down and closed eyes, usually on shelf, perch, or branches
Passive looking down	Stationary position with eyes open and head down, usually on the ground
Beak cleaning	Vigorous rubbing of the beak against protruding aviary equipment, usually after eating
Grooming	Plucking feathers with a beak
Shared grooming	Mutual cleaning of feathers with beak; between two birds
Aggression	Aggressive pecking of one individual by another
Getting nearer	Approaching one bird sideways to the other until the sides of the bodies meet
Shaking off	Shaking the whole body vigorously
Approaching	Approaching the observer and the music source
1, 2, 3, 4 m distance	Sitting at a distance of 1, 2, 3, or 4 m from the observer

in the literature on corvid behavior.[15,16] In total, 30 behaviors were noted and described in the ethogram—standing, walking, hopping, flight, flying up the wall, pecking, warning, single, multiple, leave-me-alone, listening, begging, chasing and begging, feeding, running away, drinking, eating, flying (with food), food walking, caching, sleeping, passive looking down, beak cleaning, grooming, shared grooming, aggression, getting nearer, shaking off, approaching, and 1, 2, 3, 4 m distance. We considered behaviors such as flying up the wall, warning, running away, aggression, and passive looking down as potentially associated with higher stress because those behaviors under natural conditions are a reaction to a threat. We considered social behaviors such as shared grooming, getting nearer, approaching, and 1, 2, 3, 4 m distance as potentially associated with lower stress because those behaviors under natural conditions are related to eating and foraging. Only behaviors where notable differences were observed and confirmed to be statistically significant were described in this paper.

The significance of the differences between medians of observations with and without exposure to music was tested using the Wilcoxon test (Fig. 2A). Correlation between trends of different behaviors was assessed using the Spearman test (Fig.2B). Raw data and R code used to generate Fig. 2 are available here.

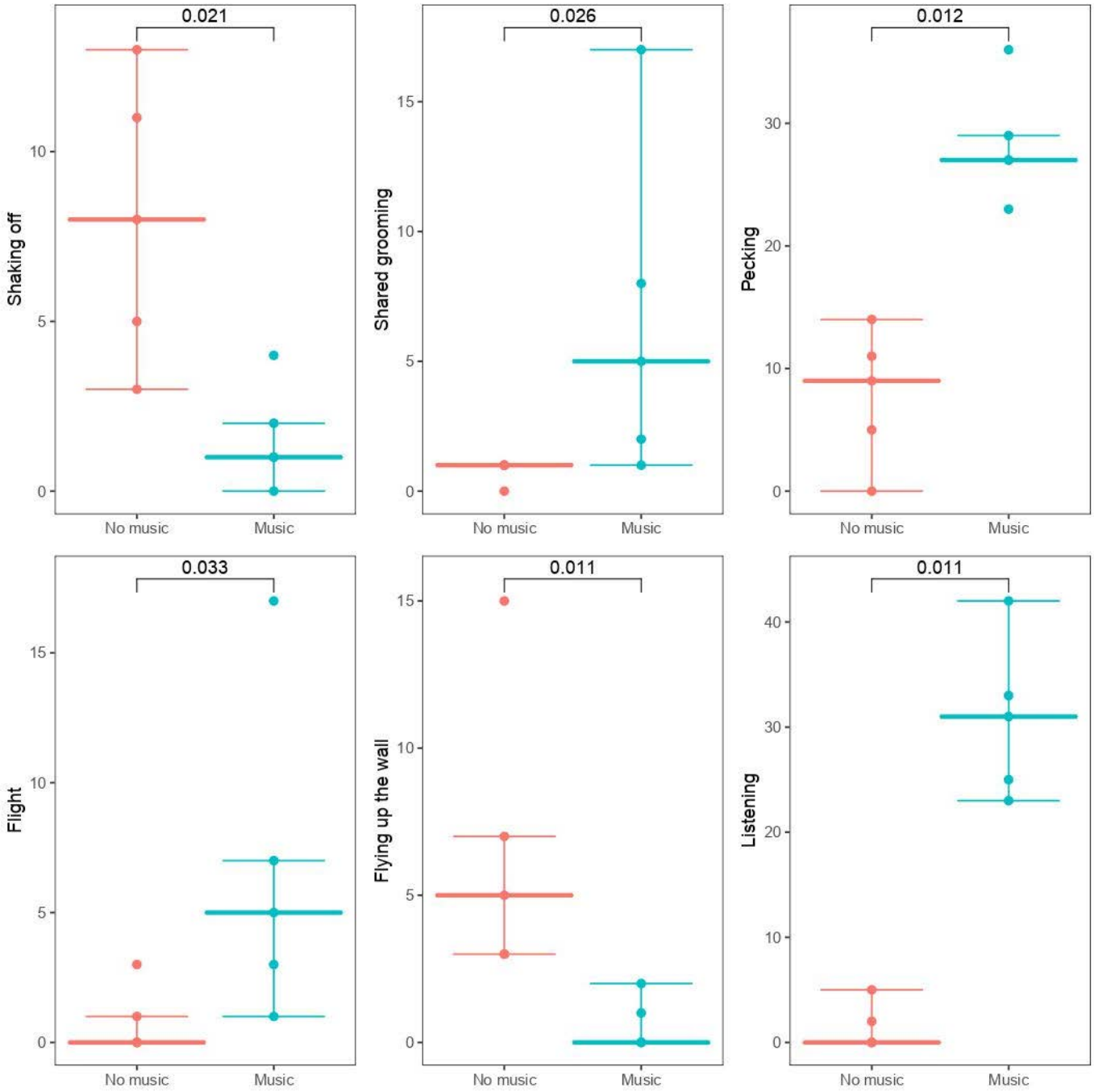
Results

Initial qualitative observations suggested that among different genres of music, the mostly instrumental jazz trumpet recordings elicited the most positive responses from the birds. This was therefore the playlist chosen in this pilot enrichment study.

The observations were conducted for two consecutive five-day periods: one without music, and one with music. Mean and median values of counted occurrences of each behavior in the periods with and without music were compared. Figure 2A shows six behaviors where notable differences were observed and confirmed to be significant under the Wilcoxon rank sum test. Flight, shared grooming, pecking, and listening behaviors were increased during music exposure, whereas flying-up-the-wall and shaking-off behaviors were decreased. The remaining behaviors were not changed following music exposure.

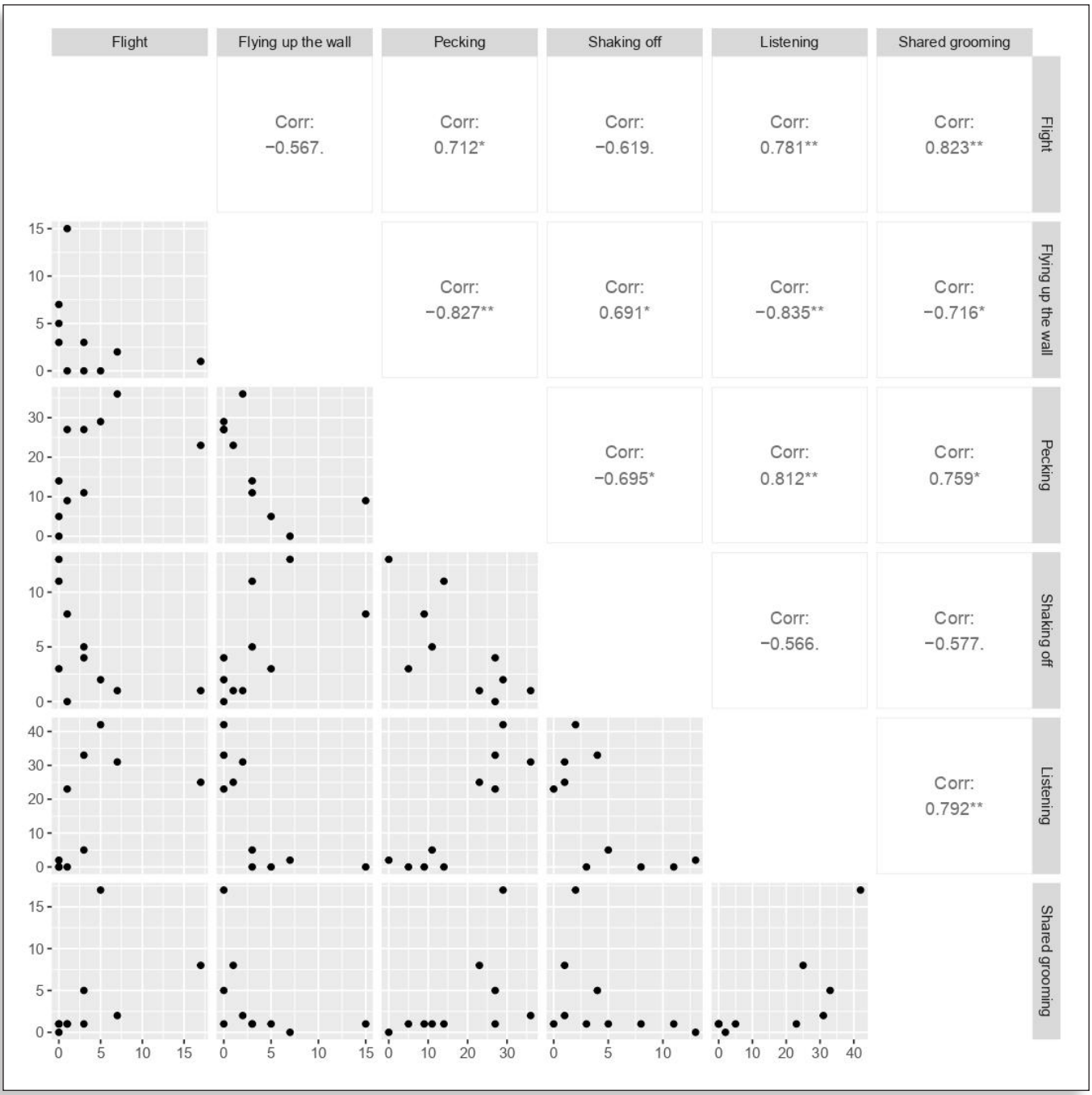
Even though the statistical power of this case study is limited due to a small number of observations (five days in each condition), we also compared day-to-day trends in the counts of the six behaviors

CONTINUED ON PAGE 18



A

FIGURE 2A. The effect of music on captive hooded crows in the rehabilitation center.
(A) Counted behaviors that changed significantly following exposure to music. Five observations (one per day) were recorded for the period without music (red) and with music (blue), as described in the text. Median values are represented by horizontal bars, whiskers correspond to 1.5x interquartile values. The p values of the Wilcoxon rank sum test are shown.



B

FIGURE 2B. The effect of music on captive hooded crows in the rehabilitation center.
(B) Pairwise correlation plot of data collected over the entire observation period (10 days in total) for the behaviors shown in (A). Spearman correlation coefficients are provided, with single and double asterisks denoting significance levels, $p < 0.05$ and $p < 0.01$, respectively.



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which were found to be influenced by the exposure to music (Fig. 2B). Significant positive correlations (under the Spearman test) were observed for flight, pecking, shared grooming, and listening behaviors that were upregulated by music. Similarly, the observations for shaking off and flying up the wall—behaviors that decreased upon music exposure—were significantly positively correlated. Significant negative correlation was demonstrated between pairs of behaviors that were differently influenced by music: pecking (upregulated) and flying up the wall and shaking off (both downregulated), as well as between listening and shared grooming (both upregulated) and flying up the wall (downregulated).

Discussion

There is no doubt that captivity is a suboptimal environment for wildlife, and it can result in the development of physical and behavioral disorders in animals.[17] Considering the sophisticated cognitive abilities of nonhuman animals, including corvids,[18] it is also clear that behavioral and mental well-being is at least as important for successful rehabilitation as physical health. In this case report, we attempted to use music as an additional environmental enrichment factor for hooded crows rehabilitated at the Ptasi Azyl Center in the Warsaw Zoo.

Although limited by a relatively short observation period and many uncontrolled variables typical in the wildlife rehabilitation center setting, the results are encouraging. We observed that four different behaviors (pecking, shared grooming, flying, and listening) occurred more frequently when music was played. All of these are behaviors that can be considered desirable and related to good welfare. Increased pecking and flying are a positive indication, as in nature, crows spend most of their time scavenging and searching for food. Shared grooming is also a normal, beneficial type of interaction in these social birds. We can thus conclude that exposure to music can, at least partially, increase the frequency of normal behavior. The freedom to express normal behavior is one of the Five Freedoms proposed by the Animal Welfare Committee (https://www.gov.uk/government/groups/animal-welfare-committee-awc) as the foundation for animal welfare. It follows, therefore, that this intervention with music has a positive effect on the welfare of rehabilitated corvids. Interestingly, the frequency of the listening behavior was also greatly increased when music was played, suggesting that its sound was the main factor influencing the observed changes.

On the other hand, behaviors that are clear indicators of stress in captivity (flying up the wall and shaking off) were observed to decrease on the days when music was played. Their decrease suggests that music had a calming effect on the birds and reduced their stress levels. This effect relates to another of the Five Freedoms—freedom from fear and distress.

Conclusions

These observations suggest that exposure to the music "Milestones of a Jazz Legend: Louis Armstrong" for a brief daily period will likely benefit the well-being of hooded crows in rehabilitation centers. Also, importantly, we found no indication of any harmful effect. We therefore propose that music is a promising tool for enriching the environment of crows during rehabilitation which can be easily implemented at low cost by personnel and volunteers without prior training.

Acknowledgements

Special thanks for their professional and technical support are due to the staff and volunteers from Ptasi Azyl in Warsaw. In particular, we would like to thank Dr Agnieszka Czujkowska for sharing their knowledge and experience in the rehabilitation of corvids.

Literature Cited

1. Żurawlew P, Czechowski P, Ławicki Ł. Występowanie czarnowrona *Corvus corone* w Polsce. [Occurrence of the black crow *Corvus corone* in Poland] *Ornis Polonica*. 2010;51:262–74.
2. Baglione V, Canestrari D, Marcos JM, Griesser M, Ekman J. History, environment, and social behaviour: experimentally induced cooperative breeding in the carrion crow. *Proceedings of the Royal Society of London. Series B: Biological Sciences.* 2002; 269(1497):1247–51.
3. Kirschhock ME, Ditz HM, Nieder A. More than nothing: behavioural and neuronal correlates of numerosity zero in the carrion crow. Proceedings of the Annual Meeting of the Cognitive Science Society. 2021;43(43).
4. Kruszewicz A. Ptaki polskie, tom 2. Warszawa: Multico. 2011. [Polish Birds, Volume 2. Warsaw: Multico. 2011.]
5. Luniak M, Kozlowski P, Nowicki W, Plit J. *In:* Birds of Warsaw 1962–2000. Polish Academy of Sciences Stanislaw Leszczycki Institute of Geography and Spatial Organization. 2001.
6. Zduniak P. Wrona *Corvus cornix* w Polsce—stan wiedzy i perspektywy badań. *In:* Jerzak L, Kavanagh BP, Tryjanowski P. (Eds.) Ptaki Krukowate Polski, Bogucki Wyd. Nauk, Poznań, s. 113–125. (2005). [Crow *Corvus cornix* in Poland—state of knowledge and research perspectives. *In:* Jerzak L, Kavanagh BP, Tryjanowski P. (eds.) Birds of corvids Polish, Bogucki Wyd. Nauk, Poznań, 2005. p. 113–25.]
7. Udolf, J. Liczebność i rozmieszczenie wrony siwej *Corvus cornix* w środkowo-wschodniej części Wrocławia. Ptaki Śląska. 2003. 15. [The number and distribution of the grey crow *Corvus cornix* in the central-eastern part of Wrocław. Birds of Silesia. 2003. 15.]
8. Miller EA. Minimum standards for wildlife rehabilitation. IWRC. 2000.
9. King CE. Environmental enrichment: is it for the birds? *Zoo Biol.* 1993.
10. Jensen KK, Klokker S. Hearing sensitivity and critical ratios of hooded crows (*Corvus corone cornix*). *J Acoust Soc Am.* 2006;119(2):1269–76.
11. Wolfe J, Garnier M, Smith J. Vocal tract resonances in speech, singing, and playing musical instruments. *HFSP journal*. 2009;3(1):6–23.
12. de Witte M, Pinho ADS, Stams GJ, Moonen X, Bos AE, van Hooren S. Music therapy for stress reduction: a systematic review and meta-analysis. *Health Psychol Rev.* 2022;16(1):134–59.
13. Gvaryahu G, Cunningham DL, Van Tienhoven A. Filial imprinting, environmental enrichment, and music application effects on behavior and performance of meat strain chicks. *Poult Sci.* 1989;68(2):211–17.
14. Tolun T, Rathert TÇ. Effect of Music on Growth Performance, Carcass and Meat Quality in Broilers. *BSJ Eng Sci.* 2019;2(4):131–35.
15. Holzhaider JC, Hunt GR, Gray RD. Social learning in New Caledonian crows. *Learn Behav.* 2010;38(3):206–19.
16. Seed AM, Clayton NS, Emery NJ. Postconflict third-party affiliation in rooks, *Corvus frugilegus. Curr Biol.* 2007;17(2):152–58.
17. Rees PA. *In:* Studying captive animals: A workbook of methods in behaviour, welfare and ecology. John Wiley & Sons; 2015.
18. Clayton N, Emery N. Corvid cognition. *Curr Biol.* 2005 Feb 8;15(3):R80–1.

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Aleksandra Jabłońska is a PhD candidate in the Nature–Culture program at the University of Warsaw. Her research interests revolve around issues of rehabilitating corvids and the impact of music on welfare. She holds a Master of Arts degree in psychology and works as a therapist in private practice. She also volunteers at wild bird rehabilitation centers. For this publication, she carried out the study and participated in the analysis of the results; performed the query of the available literature and contacted rehabilitation centers; and co-authored the manuscript.

Paweł Golik, professor of biology at the University of Warsaw, specializes in genetics and evolution. His research interests include the application of genetic and genomic methods to study human and nonhuman populations. He participated in the design of the study, analysis of the results, and the preparation of the manuscript.

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SELECTED ABSTRACTS

Anthropogenic threats to owls: Insights from rehabilitation admittance data and rodenticide screening in Texas

Gomez EA, Prestridge HL, Smith JA. *PLOS One.* 2023;18:e0289228. doi:10.1371/journal.pone.0289228

Owls (Strigiformes) provide myriad ecosystem services and are sentinels for ecosystem health. However, they are at continued risk from anthropogenic threats such as vehicle collisions, entanglement with human-made materials, and exposure to anticoagulant rodenticides (ARs), a widespread pesticide known to affect owls. Texas is an important region for numerous migratory and non-migratory owl species in the United States (US), yet assessments of threats owls face here are lacking preventing the development of informed conservation strategies. This study coupled assessment of admittance data from two wildlife rehabilitation centers in Texas with AR liver screening to (1) identify which species of owls are commonly admitted, (2) evaluate seasonality of admittance, and (3) assess causes of admittance for owls in Texas. Between 2010 and 2021, 1,620 owls were admitted into rehabilitation, representing eight species of which the great-horned owl (*Bubo virginianus*) was the most common. For all owls combined admittance rates were highest in the spring, driven by an influx of juveniles (n = 703, 43.40%). The leading cause of admittance amongst species was "no apparent injury" (n = 567, 34.94%). Where clear diagnoses could be made, the leading causes of admittances were "entrapment in human infrastructure" (n = 100, 6.11%) and "collision with vehicles" (n = 74, 4.56%). While the admittance data did not reveal any cases of AR poisoning, liver screening demonstrated high incidences of AR exposure; of 53 owls screened for ARs, 50.94% (n = 27) tested positive with 18 showing exposure to multiple ARs. Brodifacoum was the most frequently detected AR (n = 19, 43.18%) and seven owls (25.93%) tested positive within lethal ranges. Our results suggest that owls in Texas are at risk from myriad anthropogenic threats and face high exposure rates to ARs. In doing so, our results can inform conservation strategies that mitigate anthropogenic threats faced by owls in Texas and beyond.

Goal-directed travel in the nocturnal Javan slow loris (*Nycticebus javanicus*)

Poindexter SA, Nijman V, Imron MA, Nekaris KA. *Ecologies.* 2023:4(3):568–579. doi:10.3390/ecologies4030037

An animal's ability to navigate its home range in search of essential resources is a key aspect of its ecology. To reach these resources, animals employ varying navigational processes depending on their exocentric or egocentric view of their environment. The goal of this study was to determine if the javan slow loris (*Nycticebus javanicus*), a nocturnal arboreal primate found in southeast Asia, uses some form of cognitive map and spatial memory while navigating their environment. Using behavioural and GPS data of six males and seven females collected at the Little Fireface Project field station based in West Java, Indonesia, we measured their frequency of revisiting important feeding trees, route overlap, and points where individuals significantly changed directions. We found that all individuals predominantly used four tree species while feeding and foraging. The lorises also displayed a high level of route overlap, leading us to conclude that they likely utilize a route-based cognitive map where certain landmarks are integral to their nightly movement. Few studies have specifically focused on strepsirrhine spatial cognition in the wild; here, we show the navigational mechanism used by the Javan slow loris to reach distant/out-of-sight resources. The evident reliance on spatial cognition in a strepsirrhine species suggest that it could be an important selective pressure for primates at the earliest stages of primate cognitive evolution. In addition to the importance of spatial memory in theoretical discourse, understanding slow loris movement has practical applications to conservation, particularly regarding the numerous translocations undertaken by individuals rescued from the illegal wildlife trade. We discuss the importance of considering soft release training and monitoring in such releases.

Case report: Filarial infection of a parti-coloured bat: *Litomosa* sp. adult worms in abdominal cavity and microfilariae in bat semen

Pikula J, Piacek V, Bandouchova H, Bartlova M, Bednarikova S, Burianova R, Danek O, Jedlicka P, Masova S, Nemcova M, et al. *Front Vet Sci*. 2023;10. doi:10.3389/fvets.2023.1284025

Background: Filarial infections have been understudied in bats. Likewise, little is known about pathogens associated with the reproductive system in chiropterans. While semen quality is critical for reproductive success, semen-borne pathogens may contribute to reproductive failure.
Methods: For the first time we performed electroejaculation and used computer-assisted semen analysis to provide baseline data on semen quality in a parti-coloured bat (*Vespertilio murinus*).
Results: The semen quality values measured in the *V. murinus* male appeared high (semen concentration = 305.4×10^6/mL; progressive and motile sperm = 46.58 and 60.27%, respectively). As an incidental finding, however, microfilariae were observed in the bat semen examined. At necropsy, eight adult filarial worms, later genetically identified as *Litomosa* sp., were found in the peritoneal cavity, close to the stomach, of the same parti-coloured bat male dying as a result of dysmicrobia and haemorrhagic gastroenteritis in a wildlife rescue centre. Histopathology revealed microfilariae in the testicular connective tissue and the epididymal connective and fat tissues. A PCR assay targeting cytochrome c oxidase subunit 1 confirmed that adult worms from the peritoneal cavity and testicular microfilariae were of the same filarial species. Mildly engorged argasid mite larvae attached to the bat skin proved negative for filarial DNA and the adult filarial worms proved negative for endosymbiont *Wolbachia*.

Conclusion: While the standard filarial life cycle pattern involves a vertebrate definitive host and an invertebrate vector, represented by a blood-sucking ectoparasite, our finding suggests that microfilariae of this nematode species may also be semen-borne, with transmission intensity promoted by the polygynous mating system of vespertilionid bats in which an infected male mates with many females during the autumn swarming. Presence of microfilariae may be expected to decrease semen quality and transmission via this route may challenge the success of reproductive events in females after mating. Further investigation will be necessary to better understand the bat-parasite interaction and the life cycle of this filarial worm.



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Two newborn moose calves (*Alces alces*) nursing.

Interrupted lives: Welfare considerations in wildlife rehabilitation

Willette M, Rosenhagen N, Buhl G, Innis C, Boehm J. *Animals*. 2023;13(11):1836. doi:10.3390/ani13111836

Each year in the United States, thousands of sick, injured, or displaced wild animals are presented to individuals or organizations who have either a federal or state permit that allows them to care for these animals with the goal of releasing them back to the wild. The purpose of this review is to demonstrate the complexity of considerations rehabilitators and veterinarians face while trying to optimize the welfare of wild animals in need of care and rehabilitation. The process of rehabilitation is inherently stressful for wildlife. Maintaining an animal's welfare during the rehabilitation process—from initial contact and triage to the animal's euthanasia, release, or captive placement—requires deliberate, timely and humane decision making. The welfare of wild animals can be improved by preventing human-related causes of admission, providing resources and support for wildlife rehabilitation (almost all rehabilitation in the United States is privately funded and access to veterinary care is often limited); further developing evidence-based wildlife rehabilitation methods and welfare measures, attracting more veterinary professionals to the field, harmonizing regulatory oversight with standards of care, training, and accountability, and increasing public education.

Estimating and managing broad risk of chronic wasting disease spillover among cervid species

Mysterud A, Solberg EJ, Meisingset EL, Panzacchi M, Rauset GR, Strand O, Van Moorter B, Rolandsen CM, Rivrud IM. *Ecosphere*. 2023;14(9):e4463. doi:ina.1002/ecs2.4663

The management of infectious wildlife diseases often involves tackling pathogens that infect multiple host species. Chronic wasting disease (CWD) is a prion disease that can infect most cervid species. CWD was detected in reindeer (*Rangifer tarandus*) in Norway in 2016. Sympatric populations of red deer (*Cervus elaphus*) and moose (*Alces alces*) are at immediate risk. However, the estimation of spillover risk across species and implementation of multispecies management policies are rarely addressed for wildlife. Here, we estimated the broad risk of CWD spillover from reindeer to red deer and moose by quantifying the probability of co-occurrence based on both (1) population density and (2) habitat niche overlap from GPS data of all three species in Nordfjella, Norway. We describe the practical challenges faced when aiming to reduce the risk of spillover through a marked reduction in the population densities of moose and red deer using recreational hunters. This involves setting the population and harvest aims with uncertain information and how to achieve them. The niche overlap between reindeer and both moose and red deer was low overall but occurred seasonally. Migratory red deer had a moderate niche overlap with the CWD-infected reindeer population during the calving period, whereas moose had a moderate niche overlap during both calving and winter. Incorporating both habitat overlap and the population densities of the respective species into the quantification of co-occurrence allowed for more spatially targeted risk maps. An initial aim of a 50% reduction in abundance for the Nordfjella region was set,

but only a moderate population decrease of less than 20% from 2016 to 2021 was achieved. Proactive management in the form of marked population reduction is invasive and unpopular when involving species of high societal value, and targeting efforts to zones with a high risk of spillover to limit adverse impacts and achieve wider societal acceptance is important.

Emergency-line calls as an indicator to assess human–wildlife interaction in urban areas

Pop MI, Gradinaru SR, Popescu VD, Haase D, Iojă CI. *Ecosphere.* 2023;14(2):e4418. doi:10.1002/ecs2.4418

Human–wildlife interactions (HWIs) are increasingly common human disturbances as development continues to remove wildlife habitats. Documenting HWI is critical for environmental protection agencies to develop strategies and management decisions that meet the needs of both people and wildlife. However, evaluation of the frequency and types of HWI at broad spatial scales (e.g., national or regional level) can be costly and difficult to implement by managers. In this study, we apply a novel method for the evaluation of patterns of HWI in urban areas by using publicly available data from emergency calls (ECs) placed by inhabitants of Romania's urban areas. We used information from 4601 ECs placed at the Romanian National Emergency Call System 112, which consisted of (1) wildlife species, (2) spatial location, (3) date and time, and (4) a short description of the emergency. Of the 318 analyzed cities, 300 cities documented ECs on HWI between 2015 and 2020, with roe deer and brown bear being the most frequently mentioned species. We recorded an increasing trend in HWI-related ECs in 73% of the urban areas over the five-year period. We mapped the large-scale distribution of HWI by species and type of interactions in order to capture variations at the national level. Further, we analyzed the social and the biophysical factors potentially influencing the occurrence and frequency of HWI. The results showed that social factors have the same effect on all species, while the effect of the biophysical factors varied between species. Particularly, the presence of large natural habitats, represented by forests, influenced the number of calls only for brown bears. Seminatural landscapes with agricultural land have a different influence in terms of effect and significance for the considered species. Our results suggest that publicly available data from ECs can be used for the rapid assessment of HWI and for evaluating trends and predictors of HWI at broad spatial scales.

Insights from the media into the bird trade in India: An analysis of reported seizures

Kalra S, Davies A, Martin RO, Poonia A. *Oryx.* 2023;1–9. doi:10.1017/S0030605322001594

India has an extensive bird trade that provides income and livelihoods for many people but involves considerable unregulated and illegal activity, threatening both native and exotic species and posing potential health risks to people and wildlife. Action to curb illegal trade is vital, but there is currently a lack of information on trade routes and the species involved to inform the development of strategies to address such trade. We therefore examined media reports of bird trade seizures published during 2010–2020 as a cost-effective approach to gaining insights into the composition and structure of the bird trade in India. We collected 182 media reports referring to 109 seizure events by searching for keywords on popular search engines and Indian newspaper websites. We found that 25,850 birds were seized, most frequently members of the family Psittacidae. Of the 58 species identified, 18 were native and 40 non-native to India. The greatest numbers of birds were seized in Uttar Pradesh. Analyses of trade networks indicate that Uttar Pradesh is an important trade hotspot particularly for native species and has strong transnational connections with neighbouring Nepal. We identified West Bengal as an important trade hotspot, particularly for non-native species, probably because of its extensive land borders with neighbouring countries, including Bangladesh. Our study highlights priority areas for interventions as well as key knowledge gaps that need to be addressed to facilitate the development of strategies to manage illegal, unsustainable and otherwise harmful trading of birds.

2021 Turkey mega forest fires: Biodiversity measurements of the IUCN Red List wildlife mammals in Sentinel-2 based burned areas

Aydin-Kandemir F, Demir N. *Adv Space Res.* 2023(71):3060–3075. doi:10.1016/j.asr.2023.01.031

Mega wildfires are one of the environmental disasters worldwide. This study evaluates the pre-fire species diversity and the indirect effects, including habitat loss for one of the largest wildfires in Manavgat (Antalya, Turkey) in 2021, with a two-step methodology. Here, (1) burnt areas in the Manavgat district (2021) were detected with remote sensing data from Sentinel-2A by delta Normalized Burn Ratio calculation for a selected area in Google Earth Engine, and (2) mammals' habitat vector data of International Union for Conservation of Nature (IUCN) Red List were integrated into Habitat and Biodiversity modelling of Terrset to analyze the alpha, beta, gamma diversity and Range Restriction Index for the wildfire region. In the total 4210 km^2 study area, 696 km^2 of the area was damaged by different fire severity; also, there were 56 mammal species' habitats here. These species include bats (i.e. *Nyctalus leisleri)*, felids (i.e. *Felis chaus*), rodents (i.e. *Rattus norvegicus*) and large mammals (i.e. *Ursus arctos*). 88 % of these species are in IUCN's Least Concern category. The remaining classes are Near Threatened (3.7%) and Vulnerable (7.4 %). This study also indicated that the burnt area's species richness does not totally consist of endemic species. Therefore, pre-fire species richness analyses of this study can be a base for further studies about the species' post-fire activity and occupancy. Furthermore, the 2021 mega wildfires show us the necessity of wildfire monitoring and risk studies in the entire Mediterranean ecosystem to evaluate the risks to the Sustainable Development Goals. Therefore, post-fire spatial data, fire migration monitorization, and recording of the

species' activities should be performed temporally. In this way, the ability of wildlife's recovering, and the direct and indirect effects of the fire will be examined for ecosystems in the long term.

Experimental evaluation of pathogenicity and acquired immunity of *Eimeria* species, *E. uekii* and *E. raichoi*, infecting Japanese rock ptarmigans in a subspecies of the birds

Matsubayashi M, Kinoshita M, Tsuchida S, Kobayashi A, Tamura N, Shibahara T, Kido Y, Kaneko A, Sasai K, Ushida K. *Int J Parasitol Parasites Wildl.* 2023. doi:10.1016/j.ijppaw.2023.09.005

Japanese rock ptarmigans (*Lagopus muta japonica*) are birds that inhabit only alpine regions of central Honshu Island, Japan, known as the Japanese Alps. The number of these birds has recently declined, and *in situ* and *ex situ* national conservation programs for Japanese rock ptarmigans have been initiated. The infections of *Eimeria* spp. as protozoan parasites of the phylum Apicomplexa, *E. uekii* and *E. raichoi*, were frequently reported in the birds. However, the virulence of these *Eimeria* parasites has not been determined. Here, we analyzed the pathogenicity of these *Eimeria* parasites using experimental infections of a subspecies model of Japanese rock ptarmigans, Svalbard rock ptarmigans (*Lagopus mutus hyperboreus*), and evaluated acquired protective immunity against challenge in birds tolerant of low-dose inoculation with *Eimeria* parasites. Following inoculation with two *Eimeria* parasites derived from Japanese rock ptarmigans (dose range of 4×10^4 to 4×10^2 for *E. uekii* and 1.7×10^4 to 4×10^1 for *E. raichoi*), oocysts were detected at 6–8 days post-inoculation (PI), and the maximum number of oocysts per gram of feces was observed 7–10 days PI and then gradually decreased. The mortality rate and reduction in weight gain of chicks increased following high-dose inoculation of oocysts with abnormal feces (soft and diarrhea). Developmental zoites were detected histopathologically in epithelial tissues and sometimes the lamina propria from the duodenum to the colon.



PHOTO ©TERUHIDE TOMORI. USED WITH PERMISSION.

Japanese rock ptarmigan (*Lagopus muta*).

Chicks that survived low-dose inoculation did not show clear clinical symptoms after challenge inoculation. Our results suggest that the pathological characteristics of *Eimeria* parasites infecting Japanese rock ptarmigans include abnormal feces and reduction in weight gain, resulting in mortality in cases of heavy infection due to high-dose inoculation. These findings provide helpful data for Japanese rock ptarmigan conservation efforts.

The local skin cellular immune response determines the clinical outcome of sarcoptic mange in Iberian ibex (*Capra pyrenaica*)

Valldeperes M, Granados JE, Pérez V, López-Olvera JR, Ráez-Bravo A, Fandos P, Pérez JM, Mentaberre G, Tampach S, Soriguer RC, Espinosa J. *Front Vet Sci.* 2023;10:1183304. doi:10.3389/fvets.2023.1183304

Introduction: Sarcoptic mange, caused by *Sarcoptes scabiei*, is a disease with implications for wildlife conservation and management. Its severity depends on the host's local skin immune response, which is largely unknown in Iberian ibex (*Capra pyrenaica*), a mountain ungulate dramatically affected by mange. In this species, the clinical outcome of sarcoptic mange varies among individuals, and the local immune response could be key to controlling the infestation. This study aims to characterize the local cellular immune response and its relationship with the clinical outcome.
Methods: Fourteen Iberian ibexes were experimentally infested with *S. scabiei* and six more served as controls. Clinical signs were monitored, and skin biopsies were collected from the withers at 26, 46, and 103 days post-infection (dpi). The presence and distribution of macrophages (including M1 and M2 phenotypes), T lymphocytes, B lymphocytes, plasma cells, and interleukine 10 were quantitatively evaluated using immunohistochemical techniques.
Results: An inflammatory infiltrate that decreased significantly from 26 to 103 dpi was observed in all the infested ibexes. The predominant inflammatory cell population in the skin of the mangy ibexes was formed by macrophages (mainly the M2 phenotype) followed by T lymphocytes, with lower numbers of B lymphocytes and plasma cells. Three clinical courses were identified: total recovery, partial recovery, and terminal stage. The inflammatory infiltrates were less pronounced in the

fully recovered ibexes than in those that progressed to the terminal stage throughout the study.

Discussion: The results suggest an exacerbated but effective Th1-type cellular immune response controlling mange in Iberian ibex. Furthermore, the local immune response appears to determine the variability of the clinical responses to *S. scabiei* infestation in this species. This first report on the progression of local skin immune cells is relevant not only for individuals but also for population management and conservation.

Unravelling the diversity of microorganisms in ticks from Australian wildlife

Ghafar A, Davies N, Tadepalli M, Breidahl A, Death C, Haros P, Li Y, Dann P, Cabezas-Cruz A, Moutailler S, et al. *Pathogens.* 2023; 12(2):153. doi:10.3390/pathogens12020153

Ticks and tick-borne pathogens pose a significant threat to the health and welfare of humans and animals. Our knowledge about pathogens carried by ticks of Australian wildlife is limited. This study aimed to characterise ticks and tick-borne microorganisms from a range of wildlife species across six sites in Victoria, Australia. Following morphological and molecular characterisation (targeting 16S rRNA and cytochrome c oxidase I), tick DNA extracts (n = 140) were subjected to microfluidic real-time PCR-based screening for the detection of microorganisms and Rickettsia-specific real-time qPCRs. Five species of ixodid ticks were identified, including *Aponomma auruginans*, *Ixodes (I.) antechini, I. kohlsi, I. tasmani* and *I. trichosuri*. Phylogenetic analyses of 16S rRNA sequences of *I. tasmani* revealed two subclades, indicating a potential cryptic species. The microfluidic real-time PCR detected seven different microorganisms as a single (in 13/45 ticks) or multiple infections (27/45). The most common microorganisms detected were Apicomplexa (84.4%, 38/45) followed by *Rickettsia* sp. (55.6%, 25/45), *Theileria* sp. (22.2% 10/45), *Bartonella* sp. (17.8%, 8/45), *Coxiella*-like sp. (6.7%, 3/45), *Hepatozoon* sp. (2.2%, 1/45), and *Ehrlichia* sp. (2.2%, 1/45). Phylogenetic analyses of four *Rickettsia* loci showed that the *Rickettsia* isolates detected herein potentially belonged to a novel species of *Rickettsia*. This study demonstrated that ticks of Australian wildlife carry a diverse array of microorganisms. Given the direct and indirect human–wildlife–livestock interactions, there is a need to adopt a One Health approach for continuous surveillance of tick-associated pathogens/microorganisms to minimise the associated threats to animal and human health.

Influence of COVID-19 lockdown and hunting disturbance on the activity patterns of exotic wild boar (*Sus scrofa*) and axis deer (*Axis axis*) in a protected area of northeastern Argentina

Nicosia G, de Miguel A, Fumagalli A, Diego-Arnaldo RB, Gürtler RE. *Eur J Wildl Res.* 2023;69:96. doi:10.1007/s10344-023-01725-8

Wildlife diel activity patterns are relevant for studying animal responses to human disturbance and management of overabundant and invasive species. Exotic wild boar (*Sus scrofa*) and axis deer (*Axis axis*) in a protected area of northeastern Argentina have been intensely managed through controlled shooting over bait since 2006. This program kept wild boar at bay but failed to curb axis deer numbers for unknown reasons possibly related to the timing of hunting sessions. We used camera traps to assess the seasonal diel activity patterns of both ungulates over 2017–2021 and to test whether hunting-related activity and COVID-19 lockdown modified those patterns, and whether hunting-shift intervals overlapped with ungulate core activity. Wild boar activity strongly differed between summer and winter, showing cathemeral activity in summer and nocturnal activity in winter. Axis deer cathemeral activity displayed moderate inter-seasonal and inter-annual changes. The activity cores largely differed between both ungulate species. The lockdown-related suspension of hunting and other park operations over roughly one year did not modify the seasonal activity patterns of wild boar, whereas axis deer increased its daytime activity in summer. Ungulate activity remained consistent over successive 48-h interval preceding, accompanying, and following hunting sessions, suggesting that short-term hunting-related disturbance did not influence their temporal activity. Unlike wild boar, detection of axis deer was substantially higher during intervals matching overnight hunting shifts rather than during evening shifts. Matching the timing of hunting sessions to ungulate activity cores (i.e., night hunting) may substantially increase culling and the efficiency of management efforts.

Greater spear-nosed bats commute long distances alone, rest together, but forage apart

O'Mara MT, Dechmann DKN. *Anim Behav.* 2023;204:37–48. https://doi.org/10.1016/j.anbehav.2023.08.001

Animals frequently forage in groups on ephemeral resources to profit from social information and increased efficiency. Greater spear-nosed bats, *Phyllostomus hastatus*, develop group-specific social calls, which are hypothesized to coordinate social foraging to feed on patchily distributed balsa flowers. To test this, we tagged all members of three social groups of *P. hastatus* on Isla Colón, Panamá, using high-frequency GPS during a season when balsa had begun to flower. We found that bats commuted 20–30 km to foraging sites, more than double the distance reported previously. In contrast to our expectations, we found that tagged individuals did not commute together, but did join group members in small foraging patches with high densities of flowering balsas on the mainland. We hypothesized that close proximity to group members would increase foraging efficiency if social foraging were used to find flower clusters, but distance between tagged individuals did not predict foraging efficiency or energy expenditure. However, decreased distance among tagged bats positively influenced the time spent outside roosting caves and increased the duration and synchrony of resting. These results suggest that social proximity appears to be more important during resting and that factors

other than increased feeding efficiency may structure social relationships of group members while foraging. It appears that, depending on the local resource landscape, these bats have an excellent map even of distant resources and that they use social information only for current patch discovery, and thus, they do not appear to rely on social information during daily foraging.

Detecting wildlife trafficking in images from online platforms: A test case using deep learning with pangolin images

Cardoso AS, Bryukhova S, Renna F, Reino L, Xu C, Xiao Z, Correia R, Di Minin E, Ribeiro J, Vaz AS. *Biol Conserv.* 2023;279:109905. doi:10.1016/j.biocon.2023.109905

E-commerce has become a booming market for wildlife trafficking, as online platforms are increasingly more accessible and easier to navigate by sellers, while still lacking adequate supervision. Artificial intelligence models, and specifically deep learning, have been emerging as promising tools for the automated analysis and monitoring of digital online content pertaining to wildlife trade. Here, we used and fine-tuned freely available artificial intelligence models (i.e., convolutional neural networks) to understand the potential of these models to identify instances of wildlife trade. We specifically focused on pangolin species, which are among the most trafficked mammals globally and are receiving increasing trade attention since the COVID-19 pandemic. Our convolutional neural networks were trained using online images (available from iNaturalist, Flickr, and Google) displaying both traded and non-traded pangolin settings. The trained models showed great performances, being able to identify over 90% of potential instances of pangolin trade in the considered imagery dataset. These instances included the showcasing of pangolins in popular marketplaces (e.g., wet markets and cages), and the displaying of commonly traded pangolin parts and derivates (e.g., scales) online. Nevertheless, not all instances of pangolin trade could be identified by our models (e.g., in images with dark colours and shaded areas), leaving space for further research developments. The methodological developments and results from this exploratory study represent an advancement in the monitoring of online wildlife trade. Complementing our approach with other forms of online data, such as text, would be a way forward to deliver more robust monitoring tools for online trafficking.

Conservation through collaboration: Regional conservation programs of the North Carolina Zoo

Roznik EA, Buckanoff H, Langston RW, Shupp CJ, Smith D. *J Zool Bot Gard.* 2023;4(2):292-311. doi:10.3390/jzbg4020025

In response to rapid biodiversity losses in recent decades, zoos have become more engaged in conservation issues. Solutions to conservation challenges are complex and require collaborative efforts across organizations. Zoos can be effective partners that can contribute diverse expertise and resources to protect wildlife and their habitats. While zoos often partner with international organizations to facilitate field-based conservation projects on the exotic animals they exhibit, some of the most meaningful conservation and education initiatives are conducted locally in partnership with local organizations. A core part of the mission of the North Carolina Zoo (Asheboro, NC, USA) is the conservation of wildlife and their natural habitats, both regionally and internationally. The goal of this article is to review the North Carolina Zoo's regional conservation programs and the importance of partnerships with other local organizations in accomplishing shared goals. North Carolina Zoo plays an important role in regional conservation by protecting and managing natural lands, protecting declining amphibians through head-starting and habitat management, rehabilitating native wildlife, and working on local outreach and sustainability projects to reduce impacts on natural resources and inspire others to get involved in conservation. These programs were developed through partnerships with local and state government agencies, academic institutions, non-profit organizations, other zoos and aquariums, schools, libraries, and businesses. These collaborations have been instrumental in developing and implementing successful projects by pooling limited resources and sharing crucial expertise. They demonstrate how zoos are evolving to become leaders and partners in conservation, research, and education to protect local species and natural resources.

Structural basis of white-tailed deer, *Odocoileus virginianus*, ACE2 recognizing all the SARS-CoV-2 variants of concern with high affinity

Han P, Meng Y, Zhang D, Xu Z, Li Z, Pan X, Zhao, Z, Li L, Tang L, Qi, J, Liu K, Gao GF. *J Virol.* 2023;97(9);e0050523. doi:10.1128/jvi.00505-23

SARS-CoV-2 has been expanding its host range, among which the white-tailed deer (WTD), *Odocoileus virginianus*, became the first wildlife species infected on a large scale and might serve as a host reservoir for variants of concern (VOCs) in case no longer circulating in humans. In this study, we comprehensively assessed the binding of the WTD angiotensin-converting enzyme 2 (ACE2) receptor to the spike (S) receptor-binding domains (RBDs) from the SARS-CoV-2 prototype (PT) strain and multiple variants. We found that WTD ACE2 could be broadly recognized by all of the tested RBDs. We further determined the complex structures of WTD ACE2 with PT, Omicron BA.1, and BA.4/5 S trimer. Detailed structural comparison revealed the important roles of RBD residues on 486, 498, and 501 sites for WTD ACE2 binding. This study deepens our understanding of the interspecies transmission mechanisms of SARS-CoV-2 and further addresses the importance of constant monitoring on SARS-CoV-2 infections in wild animals.

Importance: Even if we manage to eliminate the virus among humans, it will still circulate among wildlife and continuously be transmitted back to humans. A recent study indicated that WTD may serve as reservoir for nearly extinct SARS-CoV-2 strains. Therefore, it is critical to evaluate the binding abilities of SARS-CoV-2 variants to the WTD ACE2 receptor and

elucidate the molecular mechanisms of binding of the RBDs to assess the risk of spillback events.

Status, trend, and monitoring effectiveness of marbled murrelet (*Brachyramphus marmoratus*) at-sea abundance and reproductive output off central California, 1999–2021

Felis J, Adams J, Becker BH. Open-File Report. US Geological Survey;2023. https://doi.org/10.3133/ofr20231065

Marbled murrelets (*Brachyramphus marmoratus*) have been listed as "endangered" by the State of California and "threatened" by the U.S. Fish and Wildlife Service since 1992 in California, Oregon, and Washington. Information regarding murrelet abundance, distribution, and habitat associations is critical for risk assessment, effective management, evaluation of conservation efficacy, and, ultimately, the meeting of federal- and state-mandated recovery efforts. From 1999 to present, line-transect surveys have been performed to estimate at-sea abundance and reproductive output of marbled murrelets in the marine environment in U.S. Fish and Wildlife Service Conservation Zone 6 (San Francisco Bay to Point Sur in central California). Using this long-term annual time series, we developed a new and comprehensive analytical framework to estimate annual murrelet abundance and trend at sea, evaluated the effectiveness of spatial and temporal components of the monitoring study design, assessed two measures of annual murrelet reproductive output, and developed new spatial models to map murrelet at-sea density and estimate model-based annual at-sea abundances. The long-term average, design-based after-hatch-year (AHY) abundance estimate for the study area was 376 murrelets (range: 163–586 annually), and we did not detect any significant trend during the 23 years of monitoring. Spatial-model-based AHY abundance estimates were similar to design-based estimates but with smaller estimated variance. The AHY murrelets were most abundant nearshore, with little annual variation; alongshore, distribution was more annually variable, and some long-term hotspots occurred, particularly around Point Año Nuevo. The AHY murrelet densities were greatest in July and least in June and August. The long-term average hatch-year (HY) abundance estimate was 13 murrelets (range: 0–31 annually), and the long-term average HY:AHY ratio was 0.052; both metrics indicated similar interannual patterns. Evidence of a significant trend in either metric of reproductive output was not detected; although large overlap among interannual abundance and ratio estimates at the 95-percent confidence interval level made it difficult to evaluate interannual differences. Despite the apparent long-term stability in murrelet abundance in this region from 1999 to 2021, future long-term annual monitoring at sea will be critical to determine if the large-scale August 2020 CZU Santa Cruz Mountain wildfire that occurred adjacent to our study area affects local murrelet at-sea abundance and distribution. We also evaluated potential changes to survey and analytical design that could benefit this monitoring program in the future. Results indicated that eliminating the offshore stratum, focusing more effort on the nearshore stratum, and doing fewer surveys focused on a narrower time frame could maintain or improve AHY trend estimates while preserving the ability to compare them to past years.

Wildlife rehabilitation records reveal impacts of anthropogenic activities on wildlife health

Miller TK, Pierce K, Clark EE, Primack RB. *Biol Conserv.* 2023;286:110295. doi:10.1016/j.biocon.2023.110295

Wildlife faces many threats from anthropogenic activities and human-driven climate change. In this article, we use data from wildlife rehabilitation (rehab) centers, which admit and treat injured and sick wildlife, to understand the prevalence, patterns, and impacts of these threats and prioritize wildlife conservation efforts. Past studies have generally been more limited in geographic and taxonomic scope.

We analyzed 674,320 digitized records from 94 wildlife rehab centers across the U.S. and Canada to learn about threats to over 1000 animal species. We identified key threats by examining conditions causing animals to be brought to centers. Overall, the largest proportion of wildlife injury and sickness were accounted for by human activities, including vehicle collisions, fishing-related incidents, and window or building collisions. Seasonal patterns in lead and pesticide exposure highlighted threats posed by hunting with lead ammunition and rodenticide use. We identified threats to iconic and threatened species such as bald eagles, brown pelicans, big brown bats, and common loons. We found that more animals arrived at rehab centers in the week after extreme weather events compared to the week before, for certain weather events in certain locations: e.g., hurricanes and floods in southern Florida. Across all species, wildlife rehabilitators were able to return about a third of treated animals back to the wild.

These findings point to possible interventions to conserve wildlife populations and improve wildlife health, such as additional wildlife road crossings, improved regulations relating to fishing, hunting, and pesticide use, and incorporating wildlife into disaster management plans.

The promise of posthumanism in wildlife ecotourism: A set of case studies of veterinarians' role at wildlife rehabilitation centers in Costa Rica

Thomsen B, Copeland K, Fennell SR, Thomsen J, Harte M, Deshwalt A, Maxwell J, Breidenbach B, Taylor M, Copeland S, Hosack C, Schneider A, Coose S, Nickerson D, Duggan M, Heid T, Muurlink O. *J Ecotourism.* 2023: 1–19. doi:10.1080/14724049.2023.2214707

This study explored wildlife rehabilitation centers (WRCs) in Costa Rica as a potential posthumanist model for wildlife ecotourism. Posthumanism attends to the rights, welfare, and agency of non-humans to depart from a conservation biology ethos that focuses on the species-level, to consider all particular individual animals in wildlife tourist attractions (WTAs). A team of 16 US-based researchers composed of faculty, a wildlife rehabilitation professional, and 12 university students

conducted a 16-day pilot study to understand the context of wildlife rehabilitation, veterinarian practices, and ecotourism operations at three WRCs and a veterinary teaching hospital. Three rehabilitation centers are rated using a posthuman multispecies livelihoods framework. Ethnographic insights highlight practical challenges in operating rehabilitation centers and also the ethical challenges in promoting individual rights, welfare, and agency. Findings suggest that the level of treatment toward each individual animal in WRCs and ecotourism sites differs, based on the actions and beliefs of human actors who hold power over non-humans. A major unforeseen ethical dilemma arose during the study concerning the treatment of prey species, which foregrounds the need for future research on this topic. By attending to ethical beliefs in WTAs, WRCs show their potential as a pathway for posthumanist ecotourism.

Neglected zoonotic helminthiases in wild canids: New insights from South America

Uribe M, Brabec J, Chaparro-Gutiérrez JJ, Hermosilla C. *Front Vet Sci.* 2023;10: 1235182. doi:10.3389/fvets.2023.1235182

The global threat of neglected tropical diseases (NTDs) constitutes a public health issue in underdeveloped countries. Zoonotic helminthiases are the most common human NTD agents in developing countries in sub-Saharan Africa, Asia, and the Americas, causing a global burden of disease that exceeds that of more recognized infectious diseases such as malaria and tuberculosis. Wild canids are well-known mammals that act as natural reservoirs of zoonotic-relevant helminthiasis worldwide, thus playing a pivotal role in their epidemiology and transmission to humans. Here we evaluate the occurrence of zoonotic gastrointestinal helminths in two Neotropical wild canid species from the Amazonian and Andean regions of Colombia, i.e., the bush dog (*Speothos venaticus*) and the crab-eating fox (*Cerdocyon thous*). We recovered tapeworm proglottids from bush dog fecal samples and identified them molecularly as the canine-specific lineage of *Dipylidium caninum* by using cytochrome c oxidase subunit I (cox1) gene sequences. Moreover, examination of a crab-eating fox during necropsy revealed the presence of non-embryonated eggs of the neglected nematode *Lagochilascaris cf. minor*, in addition to eggs and gravid proglottids of the cestode *Spirometra mansoni*. These findings represent the first report of zoonotic-relevant cestodes, i.e., *D. caninum* ("canine genotype"), *S. mansoni*, and the nematode *L. cf. minor*, in bush dogs and crab-eating foxes as final hosts. The occurrence of these zoonotic helminthiases in wild canid species calls for regular monitoring programs to better understand the epidemiology and transmission routes of neglected dipylidiasis, lagochilascariosis, and sparganosis in South America.

The changing dynamics of highly pathogenic avian influenza H5N1: Next steps for management & science in North America

Harvey JA, Mullinax JM, Runge MC, Prosser DJ. *Biol Conserv.* 2023;282:110041. doi:10.1016/j.biocon.2023.110041

Highly pathogenic avian influenza virus (HPAIV) H5N1 was introduced in North America in late 2021 through trans-Atlantic pathways via migratory birds. These introductions have resulted in an unprecedented epizootic, a widespread disease event in animals, heavily affecting poultry, wild birds, and recently mammals. The North American incursions occurred during the largest epidemic season (2021–2022) in Europe where H5N1 may now be endemic (i.e., continuously present). The continuing outbreak includes expansion into Mexico, Central and South America beginning in late 2022. Here, we provide an overview of the Eurasian origin H5N1 introduction to the Americas, including a significant shift in virus dynamics and severe disease in wild birds. Then, to investigate the global changes in confirmed detections in wild birds and poultry across time and geographic regions, we analyzed FAO's EMPRES-i + database. To examine the 2021 introduction and spread in North American wild birds and poultry, we collated publicly available data across USA and Canadian federal sources. Based on our assessment, the unique magnitude of the North American H5N1 spread indicates the need for effective decision framing to prioritize management needs and scientific inquiry, particularly for species at risk and interface areas for wildlife, poultry, and humans. We illustrate the rapidly occurring and likely increasing detrimental effects that this One Health issue has on wildlife, agriculture, and potentially human health, and we offer a reframing of HPAIV disease response towards a decision analytical context to guide scientific prioritization as a potentially valuable change in focus. ■

TAIL ENDS



It's just a jump to the left,
And then a step to the right!

White-tailed deer
Odocoileus virginianus
IUCN Red List–Least Concern, Population Trend – Stable

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Javan slow loris *(Nycticebus javanicus)* at Mount Sawal Wildlife Reserve in West Java, Indonesia, after being confiscated from the illegal wildlife trade by International Animal Rescue.



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